II. *A collection of the* magnetical Experiments *communicated to the* Royal Society *by* Gowin Knight *M. B. & F. R. S. in the Years* 1746 *and* 1747.

I.

An account of ſome magnetical Experiments, *exhibited before the* Royal Society *on* Thurſday *the* 19*th of* February 1746, *and of which* the Preſident, *who had before ſeen the ſame performed with more deliberation on the* 11*th of the ſame month, was pleaſed to make the following report.*

Read Feb. 19. 1746-7.

BEING on *Wedneſday* the 11th of this inſtant *February* at the houſe of Mr. *Knight*, I did there in company with our worthy brother *William Jones* Eſq; ſee the following experiments; which Mr. *Knight* was deſirous I ſhould, as on this day, report to the *Society*: before whom he is alſo now prepared to exhibit the ſame, as well as the circumſtances of the place and the number of the company will allow.

He firſt produced two almoſt equal bars of hardened ſteel, to which he had communicated a ſtrong magnetic virtue. Theſe bars were nearly ſquare, each being of the length of about 15 inches and two tenths, and of the breadth and thickneſs of a little more than half an inch: one of theſe bars

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bars weighed 2 pounds and 6 pennyweight *Troy*, the other 4 pennyweight leſs than 2 pounds; and either of them readyly lifted with one of its ends better than 3 pounds and a half.

Theſe bars were then laid down on a table, ſo as to be nearly in one and the ſame ſtrait line, the north pole of the one being next to the ſouth pole of the other, and at the diſtance of about an inch from it: that is to ſay, that the north poles of both bars were pointed the ſame way, but without any regard to the poſition of the natural meridian.

Mr. *Knight* then produced a piece of natural magnet, which was one of the ſame he had formerly made uſe of, in ſome experiments he had before ſhewed to the *Royal Society*. This piece was in length an inch and $\frac{1}{10}$, in breadth $\frac{7}{10}$, and in thickneſs about $\frac{3}{10}$ of an inch at a medium, being conſiderably thicker at the one end than at the other.

This piece of magnet was then applied, ſo as to lie between the 2 firſt mentioned bars, with its thin end cloſe to the north pole of one of them, and its thick end cloſe to the ſouth pole of the other. After it had lain in this poſition a few moments, it was taken out, and upon preſenting it to the magnetic needle of a ſmall compaſs box, it was obſerved that its thinner end, the ſame which had juſt been contiguous to the north pole of one of the bars, attracted the north end of the needle; and that the thicker end, the ſame which had been contiguous to ſouth pole of the other bar, attracted the ſouth end of the ſame needle.

This ſame piece of ſtone was then again put in between the bars, but in a contrary poſition; the thicker end now lying next to the north pole of one of the bars, and the thinner end next to the ſouth pole of the other. After a few moments it was again taken out, and preſented as before to the compaſs-box: when it was found that the thinn end now attracted the ſouth end of the magnetic needle, and that the thicker end attracted the north end of the ſame.

The piece of ſtone was then again placed between the bars as at the firſt, and being again taken out and preſented to the compaſs-box: the thin end was again found as at the firſt to draw the north end, and the thick end to draw the ſouth end of the needle.

This ſame piece of magnet was then again placed between the bars, but in a poſition at right angles to both the former, one of its ſides being now contiguous to the north pole of one of the bars, and its other ſide to the ſouth pole of the other. After which being again in a few moments taken out, and preſented to the compaſs-box as before; it was found that the ſide which had been in contact with the north pole of one of the bars, did attract the north end of the needle, and that the other ſide which had been in contact with the ſouth pole of the other bar, did attract the ſouth end of the ſame needle: whilſt the two ends of the ſtone in which the polarity was before obſerved, were now found to be indifferent to either end of the needle; ſo that the line of direction of the poles in the ſtone now lay at right angles to the poſition in which it was ſcituated in the former experiments.

Mr. *Knight* then produced two ſteel needles, of the ſame ſort as thoſe which are uſually fixed to the cards of ſea-compaſſes. Theſe needles were of the length of 5 inches and $\frac{3}{10}$, and weighed ſeverally with their caps 7 pennyweight eight, and 7 pennyweight

weight nine grains; one of theſe was tempered and of a blew colour, and the other was quite hard. He alſo produced two iron weights, ſeverally weighing 14 pennyweight 22 grains, and 15 pennyweight 7 grains, both nearly of a cylindrical form, but with one of the ends rounded off.

The 2 large bars were then placed in a line, as in the former experiments, but with their ends ſo near together, as only to admit of the cap of one the needles between them.

The tempered needle was then placed flat upon the bars ſo that nearly one half of it reſted upon one bar, and the other half upon the other, the cap lying between the two. The needle was preſſed cloſe to the bars in this poſition, after which the bars were drawn away, both at the ſame time contrarywiſe, till they were clear of the needle; and this operation was repeated three or four times: after which that end of the needle which had reſted upon the northern part of one of the bars, was found ſtrongly to attract the north end of the needle in the compaſs-box; and the other end which had reſted upon the ſouthern part of the other bar, was found to attract in like manner the ſouth end of the ſame needle in the box. The power of attraction alſo acquired by this needle appeared to be very conſiderable, it lifting eaſily with either of its ends, the two iron weights above mentioned, when cemented the one to the other with wax, and weighing together 1 ounce 10 pennyweights 5 grains.

The hard needle was then applied to the bars like the other and with the very ſame ſucceſs, it lifted alſo, as the other had done, both the weights together.

The

The two needles were then themſelves applied to each other, firſt the northern half of the one, in a contrary direction, to the northern half of the other; and then the ſouthern half of the firſt, in a like contrary direction to the ſouthern half of the laſt; and from theſe ſeveral poſitions, they were ſeverally drawn till they were clear of each other, and this ſeveral times ſucceſſively: after which operation it was found, that the tempered needle had loſt ſo far its virtue, that its northern end had hardly any effect upon the needle in the box; that its ſouthern end even began to attract the contrary end of the needle from what it did before, and that it was no longer able to lift at either of its ends any ſenſible weight.

But as to the hard needle, that ſtill retained a conſiderable ſhare of its former virtue; its ends ſtill ſtrongly drawing the ſame ends of the needle in the compaſs-box as they drew before, and either of them lifting with eaſe the heavier of the two above-mentioned weights.

Mr. *Knight* then produced one of his common ſmall magnetic bars; the which being applied to the forementioned large bars, in the ſame manner as the needles had been applied to the ſame, but in a poſition contrary to that of its preſent polarity, it had its poles thereby counterchanged or inverted, and was found to lift at that which was now become its northern end, the weight of 6 ounces 8 pennyweight and 5 grains.

He laſtly produced one of his large artificial armed magnets, compoſed of ſeveral thin plates of ſteel cramped together, with which he acquainted us he had ſome time before lifted 36 pounds, and with which he did now actually lift before us 31 pounds 9 ounces and three fourths.

The temper'd needle ſpoken of above, and which had nearly loſt all its virtue, had the ſame again reſtored in great meaſure, upon being touched in the common way, on the armed poles of this artificial magnet; after which it diſcovered a ſtrong verticity, and was able to lift at one of its ends, the heavier of the 2 abovementioned weights, that is to ſay ſomewhat more than three quarters of an ounce.

The hard needle which ſtill retained, as has been obſerved, a conſiderable part of the virtue it had acquired by the touch of the large ſteel bars, was laſtly touched alſo in a contrary ſenſe, upon the armed poles of this artificial magnet; whereby it not only loſt the polarity yet remaining, but acquired a new one the other way, it would not however after this laſt touch lift more than nine pennyweight.

This is the true ſubſtance of the minutes I took, when theſe experiments were made, and which I preſume will now be verified by thoſe Mr. *Knight* is here prepared to ſhew.

AFTER the reading of this report, Mr. *Knight* did accordingly produce before the *Society* the two large bars and all the other particulars therein mentioned, with which he publicly repeated all the ſame experiments; which notwithſtanding the diſadvantagious circumſtances of the place, ſucceeded perfectly in every particular, and to the entire ſatiſfaction of all the company.

It was then further propoſed, that the temper'd needle, having its virtue again deſtroyed, ſhould be touched upon the fine armed *Terella* belonging to the *Society*, which was the noble preſent of their late worthy member the Right Honourable *James* Earl of *Abercorn*, which is eſteemed one of the beſt in *England*, and is ſaid to have lifted in his Lordſhip's hands upwards of 40 pounds: the ſame was immediately brought, and the needle being touched therewith, was found to have acquired a ſtrong polarity, and to lift about the ſame weight, as when it was before touched upon Mr. *Knight's* large armed artificial magnet; that is to ſay about fifteen pennyweight.

II.

An Account of ſome new Experiments *lately made with* Artificial Magnets, *by the ſame.*

June 4, 1747.

Read July 2. 1747.

THE *Apparatus* for touching of Needles, which I ſometime ſince had the Honour to ſhew before the *Royal Society*, was as perfect as I could have wiſh'd, as far as relates to the intended Uſe of it: But the manner in which the two Bars were diſpoſed in their Caſes made the Length of them ſomething incommodious, eſpecially in thoſe of the largeſt Size. This made me deſirous of trying if ſome Method could not be found out of placing the Bars parallel to each other without Danger of weakening their Force, by which means the Caſes would be reduced to half their Length. I remembered that ſome Years ago,

ago I had tried ſome Experiments to this Purpoſe, by placing ſome Bars parallel and in Contact, but ſo that their Poles were turned different ways: in which Poſition I found the Virtue of ſome of them remain'd pretty entire, but that others were weakened thereby. I imagin'd the Reaſon of their loſing their Force was this; that the magnetic Virtue was by degrees habituated to paſs out of the Side of one Bar into that of the other in Contact with it, and thereby was hinder'd from arriving at the Ends in its full Vigour. The Reaſon why ſome ſuffer'd more than others was doubtleſs to be aſcrib'd to their Difference in Temper. I repeated the Experiment about two Months ago, with a little Alteration. I placed the Bars parallel with their Poles in an alternate Poſition, as before, but not in Contact, having kept them at the Diſtance of about a Quarter of an Inch. Then I apply'd to their Ends two Pieces of ſoft Iron. Each Piece was laid acroſs from the North End of one Bar to the South of the other, in the ſame manner as the Lifter is applied to the Feet of an armed Loadſtone. The Intent of this was to draw the magnetic Virtue thereby down to the Ends of the Bars, and to convey it through the Pieces of Iron from one to the other. In this Condition I let them lie for about a Month, and then tried if they would lift the ſame Weight as before, which I found they did, and I thought with more Vigour. After this I repeated the Experiment with other Bars of various Sizes, and with the ſame Succeſs: I have therefore now ventur'd to fit them up in Caſes in the manner juſt deſcribed.

The Succeſs of this Experiment had led me to another Improvement: I provided a Caſe of Braſs that would juſt contain two Bars, ſuch as are ſold for half a Guinea. At one End of the Caſe were fixed two Feet of ſoft Iron, like thoſe of an armed Load-ſtone, the upper Surface of which was within the Caſe in Contact with the Ends of the two Bars: which being parallel to each other, and their Poles in an alternate Poſition, the North End of one Bar will be in Contact with one of the Feet, and the South End of the other Bar will be in like manner apply'd to the Surface of the other Foot. Upon fitting a Lifter to this new kind of Armour, I found I was able to ſupport a Weight of about 6 Pounds: The Bars are kept aſunder at the Diſtance of about a Quarter of an Inch, by a Slip of Wood, which ſlides in betwixt them.

An Inſtrument thus conſtructed ſeems capable of anſwering all the Purpoſes for which Loadſtones are uſed; for when the Bars are taken out of the Caſe, they are fit for touching Needles, or other magnetical Uſes, which may require ſingle Bars; when in the Caſe, the Whole together becomes an armed Magnet, able to lift a conſiderable Weight. And if we want to ſeparate iron Filings from thoſe of other Metals, the Feet and all the lower Part of the Caſe will take them up in great Plenty, and by drawing the Bars a little way out of the Caſe the Filings will fall off.

IV.

Some further Experiments *relating to the general* Phænomena *of* Magnetiſm, *by the ſame.*

Read Dec. 17. 1747. THE Cauſe of the ſurprizing *Phænomena* of the Loadſtone has hitherto eſcaped our Knowledge, though diligently inquired after by Men of the Abilities. Such a Diſcovery is not to be made without long Experience, and a great Variety of Facts: And the Nature of the Subject is ſuch, that the more Facts we are acquainted with, the more we find ourſelves perplexed. The Concluſions we draw from ſome Experiments are ſeemingly contradicted by others: and yet theſe ſeeming Contradictions are oft-times very reconcileable upon further Experience. If what I am about to lay before the *Society* will in any-wiſe contribute to remove theſe Difficulties, I am in Hopes it will not be unacceptable; though I ſhould not ſo properly explain the Nature of the Cauſe, as the Manner in which it acts. Many of theſe Experiments are not altogether new, but have not been ſo much attended to as they ſeem to deſerve.

Propoſition 1ſt.

The magnetic Matter of a Loadſtone moves in a Stream from one Pole to the other internally, and is then carried back in curve Lines externally, till it arrives again at the Pole where it firſt entered, to be again admitted.

Experiment I.

If we lay a magnetical Body under a Piece of Paper or Glaſs that is ſtrewed over with ſteel Filings or magnetical Sand, and by ſtriking the Table put the Filings in Motion, they will readily diſpoſe themſelves in ſuch a manner as to repreſent, with great Exactneſs, the Courſe of the magnetic Matter. Steel rendered magnetical is beſt for this Purpoſe, becauſe it is of a more uniform Texture, than Loadſtones, and will on that account exhibit a more regular Appearance. By this Experiment the curve Lines in which the magnetical Matter returns back to the Pole where it firſt enter'd are accurately expreſſed by the Arrangement of the Filings. The largeſt Curves are ſuch as take their Riſe from one Polar Surface, and are extended to the other; being larger in proportion as they ariſe nearer the Axis or Centre of the polar Surface. Thoſe Curves which ariſe from the Sides of a magnetical Body are always interior to thoſe which ariſe from the polar Surface; and are leſs and leſs in proportion to their Diſtance from the Ends. If any one ſhould doubt, whether the magnetical Matter, which thus diſpoſes the Filings, is really moving back in a Direction contrary to that with which it paſſes through the magnetical Body; let him try it in different Parts with a ſmall Compaſs Needle, and the Fact will appear beyond Diſpute.

Exp. II.

The larger the Diſtance is from Pole to Pole in different Magnets, the larger will theſe Curves be.

This appears from examining Magnets of different Lengths. And this is the Reaſon why in the ſame Magnet the Curves are leſs in proportion to their greater Diſtance from the Ends of the Bars. For the Poles from whence theſe Curves ariſe are proportionably nearer each other.

Exp. III.

If the South Pole of one Magnet be oppoſed to the North of another, moſt of the magnetic Matter is carried directly out of one into the other: and does not return back in curve Lines till after having paſſed through both Magnets. It appears from the Arrangement of the Filings that the magnetic Matter proceeding from the polar Surface does not now diverge from the Axis as before, but runs more in ſtreight Lines till it arrives at the polar Surface of the other Magnet. The Curves ariſing from the Sides, which before were bent towards the oppoſite End of the ſame Magnet, are many of them now bent the contrary Way towards the correſponding Sides of the other Magnet. Thoſe which are not bent the contrary Way are ſuch as are too remote from the oppoſed Pole of the other Magnet to be influenced thereby; and therefore continue their natural Courſe.

Exp. IV.

Whilſt the Bars are in the Poſition of the laſt Experiment, if a ſmall Loadſtone be placed in the Stream running from one to the other in any Poſition whatſoever, the Stream will paſs through the

Stone: which, being again removed, will be found to have a Polarity exactly in the Direction of that Stream.

Exp. V.

If the North or South Poles of two Magnets be oppoſed to each other, the Filings will exhibit the Appearance of two Streams meeting; and the Curves of each will all be turned towards the oppoſite Pole of the ſame Magnet. The Appearance is altogether the ſame, whether the two North or two South Poles be oppoſed to each other. So that it is not to be determined from any of theſe Experiments at which of the Poles the magnetic Stream enters. As we have ſome Reaſon to think it enters at the North Pole, we may ſuppoſe that the Caſe, without Danger of Errour; provided we build nothing upon the Suppoſition, but what would hold good (*mutatis mutandis*) if the contrary ſhould be true. This being ſuppoſed, when the South Poles are oppoſite, the two Streams coming out at them are directly contrary, whereby the magnetic Matter is accumulated, and therefore diverges ſo much the faſter to return back to the North Poles: When the North Poles are oppoſed to each other, the Streams of magnetic Matter returning from the South Poles are directly contrary; and by crouding at once towards each polar Surface are accumulated betwixt them, and converge towards them ſo much the faſter.

Theſe five Experiments ſeem ſufficient to eſtabliſh the Truth of the Propoſition; and many more might be produced to the ſame Purpoſe.

Prop. 2.

The immediate Cauſe, why two or more magnetical Bodies attract each other, is the Flux of one and the ſame Stream of magnetical Matter through them.

Exp. VI.

It appeared in the third Experiment, that when the South Pole of one Magnet was oppoſed to the North of another, a Stream of magnetic Matter was carried from one to the other, and did not return back to the Pole where it firſt entered, till after having paſſed through both Bars: and it is needleſs to obſerve that two Bars in this Poſition are in a State of Attraction. The fifth Experiment ſhewed, that when the two South or North Poles were oppoſed, there was no Stream common to both. Now it is well known, that magnetical Bodies in this Situation are ſo far from attracting, that they ſtrongly repel each other. If the third Experiment be repeated, with the Magnets placed at different Diſtances from each other, we ſhall find that more of the magnetical Matter will paſs from one polar Surface to the other, in proportion as the Diſtance betwixt is leſs. The Attraction is therefore greater as the Diſtances diminiſh. And at Diſtances where none of the magnetic Stream paſſes from one Magnet to the other, there is no Sign of Attraction. So that this Cauſe is not only coexiſtent with the Effect, but alſo proportionable thereto.

Exp. VII.

If a Piece of ſoft Iron which has no fixed Magnetiſm is any where placed in the magnetical Stream, it will be in a State of Attraction whilſt it remains in that Stream, and no longer.

Exp. VIII.

A Ball of ſoft Iron in Contact with the Pole of a Magnet will attract a ſecond Ball, and that a third, and ſo on, till the Stream becomes too weak to produce an Attraction ſufficient to ſupport a greater Weight.

Exp. IX.

Having hung a Number of Balls to each other, by applying the firſt to the North Pole of a Magnet, upon preſenting the South of another Magnet to one of the middle Balls; all thoſe below it will thereby be deprived of the magnetic Stream, and inſtantly loſing their Power of Attraction fall aſunder: the Ball, to which the Magnet was applied, will be attracted by it, and all the others will ſtill remain ſuſpended. But if the North End of a Magnet be preſented, then the Ball to which it is apply'd will alſo drop.

Exp. X.

In a Magnet unarmed the magnetic Stream is carried back on all Sides in curve Lines to the contrary Pole,

Pole, as was ſeen in *Experiment* I. but when Armour is applyed to each Pole, the magnetic Matter is thereby conducted to the Feet of the Armour; and a Lifter being thus apply'd to the Feet, the whole Stream coming out at one Pole is carried back through it to the other; by which means the Lifter is made to adhere to the Feet of the Armour with very great Force. When the Lifter is thus in Contact, the Magnet ſeems externally to have loſt the greateſt Part of its Force; though in Reality it never acted with more. If inſtead of the Lifter we ſuſpend a Number of Iron Balls in Contact, they will adhere together, and hang like a Bracelet betwixt the two Feet; the returning Stream paſſing now through them, as before through the Lifter. Preſent the Pole of a Magnet, and they inſtantly fall aſunder.

Prop. III.

The immediate Cauſe of magnetic Repulſion is the Conflux and Accumulation of the magnetic Matter.

It appeared in the fifth *Experiment*, that the ſame Poles of two different Magnets being oppoſed to each other, there was a Conflux and Accumulation of the magnetic Matter; and we find by Experience that all magnetical Bodies in a like Situation are in a State of Repulſion.

Exp. XI.

Two ſmall Bars, the one hard, the other of a Spring Temper, being both magnetical Matter, were oppoſed to each other, South to South; the Filings produced the ſame Appearance of Repulſion, as deſcribed in the fifth *Experiment*; then the Bars being brought ſo near as to touch each other at the ſame Poles, the Repulſion was inſtantly changed into Attraction.

III. *A Diſcourſe concerning the Uſefulneſs of* Thermometers *in Chemical Experiments; and concerning the Principles on which the* Thermometers *now in Uſe have been conſtructed; together with the Deſcription and Uſes of a* Metalline Thermometer, *newly invented by* Cromwell Mortimer *M. D.* Sec. R. S. *&c.*

Read May 8. 1735. *here printed with ſome Alterations.*

CHEMISTRY being the moſt extenſive Branch of Experimental Philoſophy, hath furniſh'd Mankind with the greateſt Number of curious and uſeful Diſcoveries; for not only the Art of ſeparating Metals from their Ores, of which Metals are form'd ſuch Variety of uſeful Inſtruments, but likewiſe Cookery, which is ſo much concern'd about the Food of Mankind during Health, and alſo Pharmacy, which furniſhes Medicines for the reſtoring Health when loſt, the Art of Dyeing, and many other uſeful Manufactures, all owe their Improvements to this Science; many of which have been light on unexpectedly by the Operator, while